PASSIVE SOLAR WATER HEATER

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BORANG PENYERAHAN TESIS

Judul: Passive Solar Water Heater

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ABSTRAK

Sarawak menerima sinaran matahari sepanjang tahun. Matahari merupakan salah satu sumber tenaga yang diperolehi secara percuma. Salah satu kegunaan tenaga matahari ialah untuk memanaskan air atau lebih dikenali sebagai "solar water heater". Kegunaan alat pemanas air ini di Sarawak masih berkurangan disebabkan oleh kerana kos dan kurangnya pengetahuan masyarakat terhadap alat ini. Projek ini bertujuan untuk membentuk satu sistem pemanasan air menggunakan tenaga solar secara pasif yang mampu dimiliki oleh setiap rumah. Sistem yang direka bertujuan mengurangkan kos pembelian dan juga kos operasi. Sistem yang direka juga harus senang dipasang dan sesuai dengan keadaan persekitaran. Sistem yang direka menggunakan pengumpul haba yang dipasang dibawah atap dan menggunakan keluasan atap sebagai pengumpul tenaga daripada matahari. Proses pemanasan air adalah berdasarkan haba yang dikumpulkan oeh atap dan haba yang terperangkap di bawah atap. Sistem yang direka juga mengurangkan beban yang ditanggung oleh atap dengan meletakkan tangki pengumpul di bahagian bawah berlainan dari sistem pemanas air suria pasif yang sedia ada.

ABSTRACT

Sarawak receives bright sunlight almost every day in a year. Sun is a source of free energy and inexhaustible. Solar energy can be use for water heating or solar water heater. The usage of this type of water heater in Sarawak is still low due to the cost and the knowledge of the people in the system. This project is to produce a passive solar water heater that is affordable by every household. The system must be low in capital cost and also in its running cost. The design system must be easy to install and suitable with its surrounding. The collector for the system is placed under the roof to make use of the wide roof area as the thermal collector from the sun. The water is heated up by the heat absorbed by the roof and also the hot air under the roof. The system also eliminated the extra reinforcement on the roof that is needed when installing other passive solar water heating system by placing the storage tank below the roof and separately from the collector.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

NOMENCLATURE

English symbols

A	Surface area
e	Emissive power
h	Convective heat transfer coefficicient
L	Wall/ surface thickness
Q	Rate of heat flow
T	Temperature

Greek symbols

ε	Surface emissivity
σ	Stefan-Boltzmann constant

Subscripts

cond	Conduction
conv	Convection
rad	Radiation

CHAPTER 1

INTRODUCTION

The solar energy is a very large, inexhaustible source of energy. The power energy from the sun is approximately 1.1 x 1011 MW. (S.P.Sukhatme, 1984). Each year large amount of solar energy reaches the earth's ground atmosphere. Much of it is reflected back into space by clouds before it reaches the earth surface. 95% of the sunlight which reach the ground is converted into heat and the other 5% radiated back into space. The capture of the solar energy gives no air and water emissions and therefore does not contribute to any of the environmental problem such as acid rain and global warming which associated with the other sources of energy. This gives the advantages of the solar power that is environmentally clean and available in almost all part of the world incorporate it to become the interesting fields to explore. One of the simplest usages of the solar energy is for water heating purposes. (N.K Bansal et al, 1981).

However, there are some problems associated with the use of the solar energy. The first is the collection of the energy from the sun. In the hottest region of the earth, the solar radiation flux available rarely exceeds 1 kW/m2. The value is considered low for the technological utilization. (S.P.Sukhatme, 1984). This mean large area for the solar energy collector is required for the applications and thus resulting higher costs.

The second problem is the solar energy availability varies with time. Due to the earth turns on its axis created day and night. Solar energy can only be collected during sunny daytime. This means the needs for the energy storage and thus required additional cost even though the energy itself is free.

The most common applications for solar energy are for water heating. Many solar water heater heating systems have been in use since the time of Second World War. For applications up to 50 or 60^0C of water temperature, solar energy can be effectively utilized for the domestic or the commercial sector. (N.K Bansal et al, 1981).

Solar water heater can be either active or passive system. An active system uses pump to circulate the heat transfer fluid or water. For passive system, the water flow is due to the design and gravitational effect. The amount of hot water collected or produce depends on the size and type of the system, sun available at the site, proper installation and the tilt angle and orientation of the collector.

Passive solar water heater was used widely from the beginning of the twentieth century till about 1950 when cheap oil and natural gas become available. Now due to the search for alternative energy research and considering environmental effect, solar water heaters are installed again in many countries such as Europe, Australia and Japan.

Passive solar water heating system is usually used in domestic area due to the cost and simple design. Compared to the active system, passive system has low cost but have smaller efficiency. With no electric device such as pump and simpler design passive system is more reliable, easier to maintain and possibly longer lasting than active systems. (S.P Sukhatme, 1984).

1.1. Definition of passive solar water heater.

Cambridge International Dictionary of English state that passive is a behavior that not acting to influence or change a situation and let other things to take control. Passive solar water heater is a system for heating water using solar radiation and the flow of the water inside the system is passive. This means that the water flow is not prolog by any mean of mechanical and electronic devices such as pump. (C. Tuminaro, 1990). Passive solar water heating systems have no moving parts and operate using local water pressure and solar radiation. There are no pumps or controls to maintain and no electrical energy is required to make it function.

1.2. Current situation.

Nowadays the usage of passive solar water heater in domestic area in Malaysia is still low. This is due to the price and the availability of the solar water heater in Malaysia. The price of a unit of a passive solar water heater cost more than RM 2500 not including the installation cost. (Microsolar, 2003). The price depends on the system, efficiency, size and the capacity. Most of the system is equip with electric water heater that installed in the storage tank. The high prices of the system make it not preferable for the home use.

1.3. Project objective.

The main objective of this project is to design an under roof collector, construct the design and evaluate the design. Currently the cost of the solar water heating system is quiet high in capital and also in installation cost. The other objective of this project is to design a low cost passive solar water heater with easy installation.

CHAPTER 2

LITERATURE REVIEW

This chapter will cover the information on Malaysia weather and about the existing passive solar water heating system. This topic will cover the overview on the system and the associate study about the passive solar water heater.

2.1. Weather conditions in Malaysia.

Malaysia located was located between 1^0 and 7^0 above the Khatulistiwa line. This give Malaysia receive bright sunlight almost all the year round. For the application for solar energy the solar radiation and the air or surround temperature must be considered.

2.1.1. Solar radiation in Malaysia

Generally solar radiation recorded over the whole Malaysia was normal throughout the years. In Figure 2.1 shown below, most places in Malaysia recorded solar radiation ranging from 16 to 17 MJm^{-2} per day. The highest solar radiation between 17 to 20.5 MJm^{-2} daily was recorded in most Semenanjung Malaysia and Sabah. However, for Sarawak had lower values of solar radiation ranging from 15 to 16 MJm^{-2} daily. (Monthly Weather Bulletin, 2003).

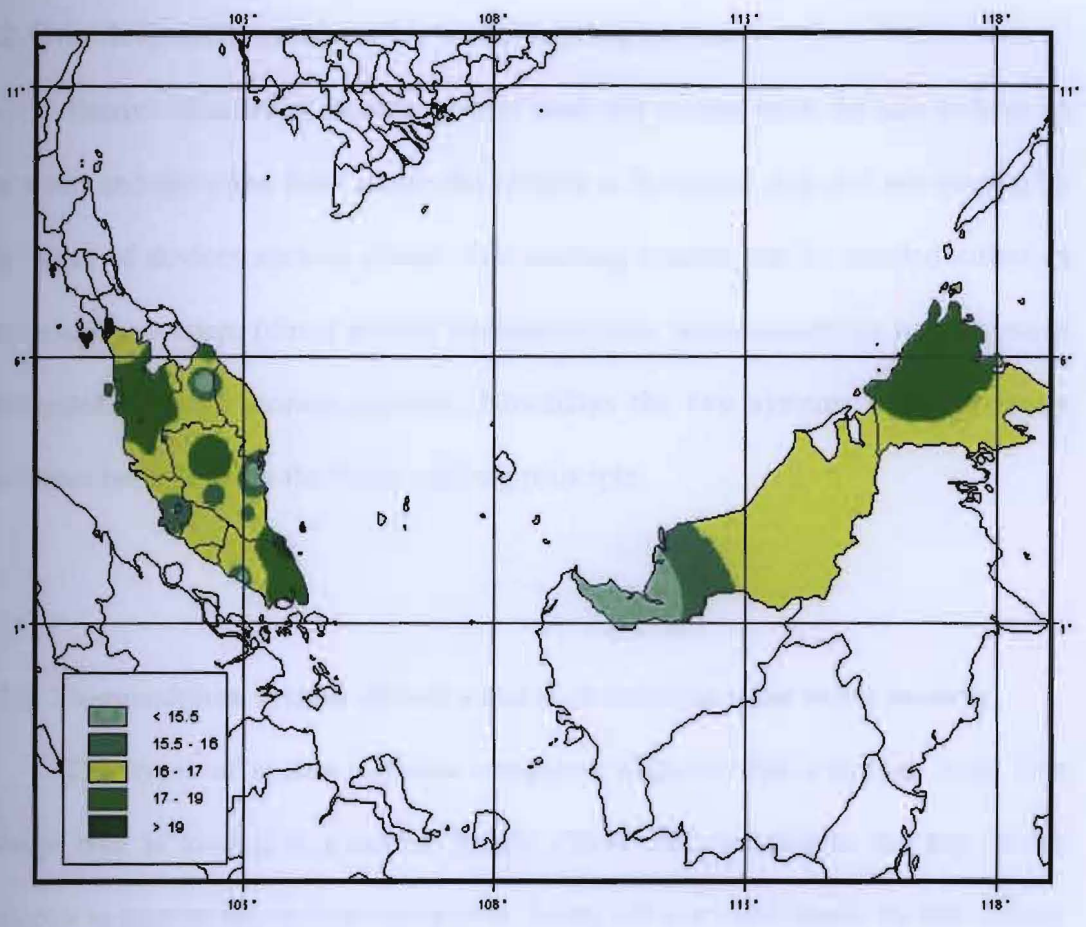

Figure 2.1 Mean daily solar radiations in Malaysia.

2.1.2. Temperature in Malaysia.

Most of the lowland areas in Malaysia recorded was above the normal temperatures. Daily mean temperatures in Malaysia were between 25.5 °C and 29.5°C. The highest temperature recorded during this period was 36.8°C being reported in 2002. On the other hand, the lowest temperature of 20.3°C was recorded in the same year. (Monthly Weather Bulletin, 2003).

2.2. Overview on the passive solar water heating system.

Passive solar water heating system used sun energy from the sun to heat up the water and the water flow inside the system is in natural way and not prolog by any mean of devices such as pump. The existing system can be divided either as thermosiphon system (direct natural circulation solar water heater) or batch system (integrated collector storage system). Nowadays the two systems come in many variations but still apply the basic working principle.

2.2.1. Thermosiphon system (direct natural circulation solar water heater).

This types of system consists a separate collector and a storage tank. The storage tank is located at a certain height (30-60 cm) relative to the top of the collector to prevent the reverse circulation during off-sun shine hours. In this system (refer to figure 2.2), the hot water storage tank can be either under city water pressure, or under a cold water storage tank pressure or it can be non pressure type in which case a float valve is provided in the tank. During daytime the sun heat up the collectors, the hot water inside rises by natural convection and the cold water in the tank leave from the bottom of the tank into the collector by gravity. The circulation loop is automatically established whenever there is a sufficient sunshine. The circulation will stop automatically during insufficient radiation when the upwards buoyant force unable to overcome the fluid friction loses inside the collector pipes. The hot water from the collector enters the upper section of the storage tank. On the lower side of the tank is filled with colder water. The course

water flows inside the system is known as the thermosiphon effect. This system is more preferable because it operates in a closed-loop system (C. Tuminaro, 1990). But one of the disadvantages of the system is it need to be placed on a high place, normally on the roof and need extra reinforced on the roof to support the storage tanks.

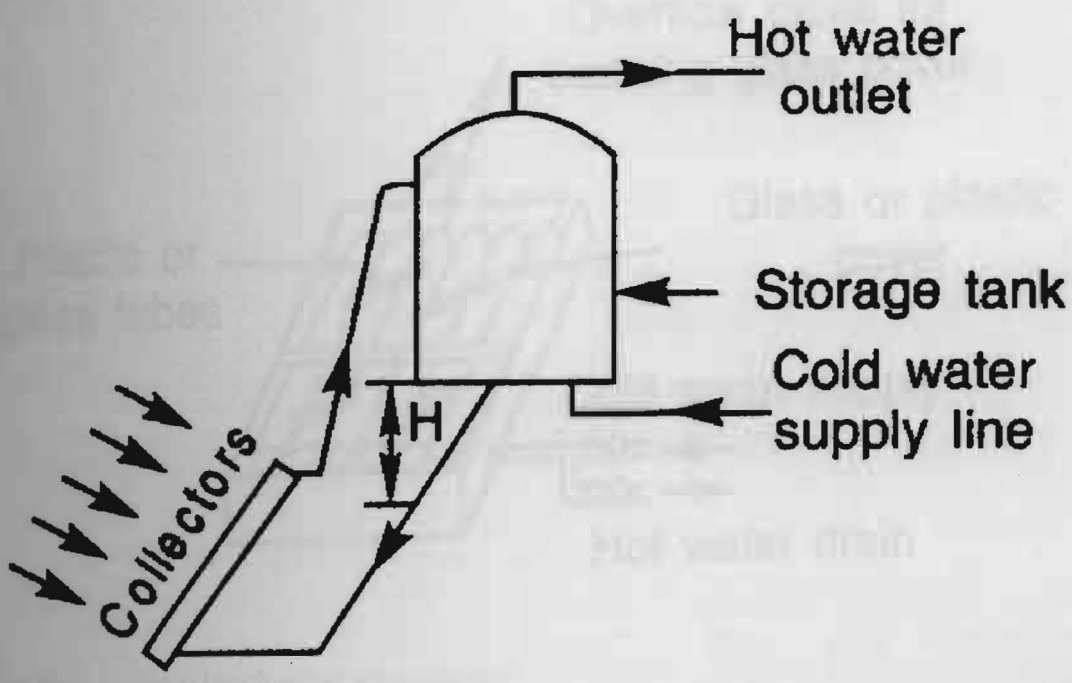

Figure 2.2 Basic thermosiphon system design.

2.2.2. Batch system (integrated storage collector system).

In the system the collector and the storage tank is combined into one. The collector performs the dual functions of absorbing the solar radiation and storing the solar heat. Therefore, these solar heaters are simple in design, low cost, easy in

operation and maintenance and easy installation. But these types of solar water heater cannot be used for storing hot water for longer duration. (J. Prakash et al, 1997). Basically a batch system consist of one or more water storage tanks placed inside an insulated box that have a glazed side that faces the sun (C. Tuminaro, 1990).

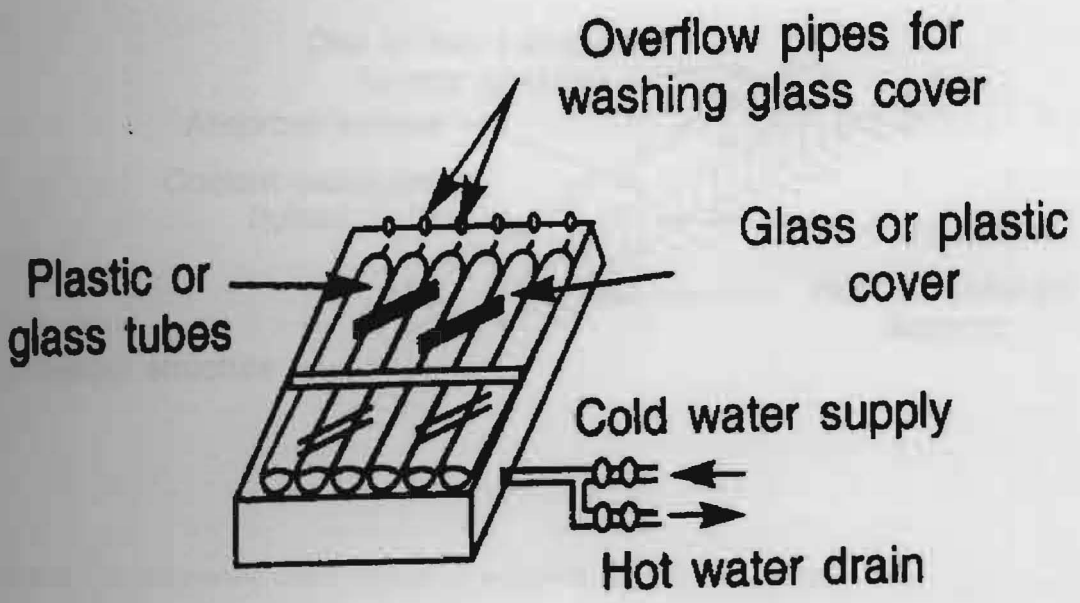

Figure 2.3. Basic batch solar water heater

2.3. Flat plat collector

The flat plate collector is the most important part of any solar water heater except for the batch type solar water heater. It is basically a heat exchanger which transfer the heat absorb from the sunlight to the water that flow through. The inventions of liquid heating flat plate solar water heater is credited to H.B. Saussure,

a Swiss scientist, during the second half of the 17th century, as reported by Ackermann in year 1915. In 18th century many study have been done to improve the efficiency of the flat plate collector. The main objective of the study is to convert as much solar radiation as possible into heat at the highest attainable temperature, with the lowest possible investment in the materials. (J. Prakash et al, 1997).

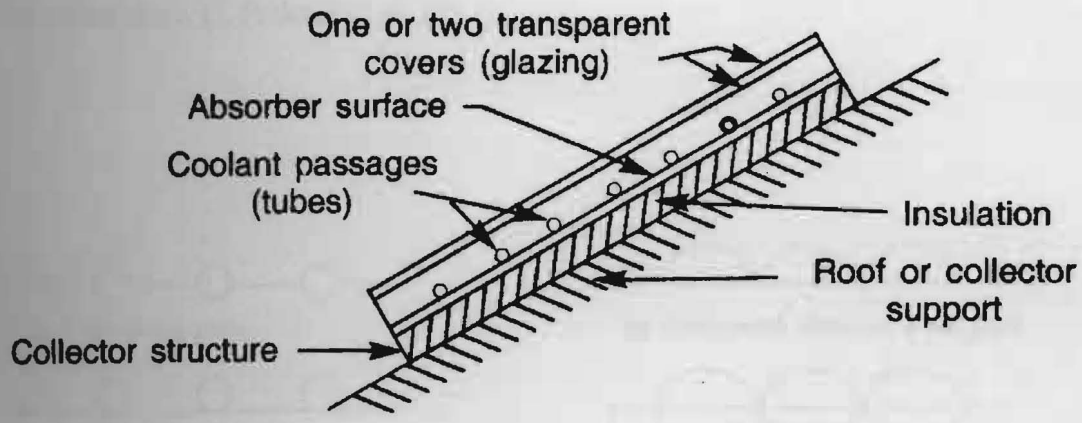

Figure 2.4. Schematic cross section of a typical flat plate collector.

Flat plate collectors consist of several basic elements as in figure 2.4. These are as follows:

i. A flat adsorbing plate, normally metallic, upon which the short wave solar radiation falls and is absorbed.

ii. Tubes, channels or passages attached to the absorber plate for the fluids flow thus absorb the thermal energy from the plate

iii. Thermal insulation provided at the back and sides of the absorber plate to minimize the heat loses.

iv. A transparent cover (1 or more) of glass or transparent plastic to reduce the upward heat loses from the absorber plate.

There are numbers of fluid channel design in the flat plate collector as shown in figure 2.5 below. The channel can be bedded, fitted, bonded or fastened to the absorbing plate. (J. Prakash et al, 1997).

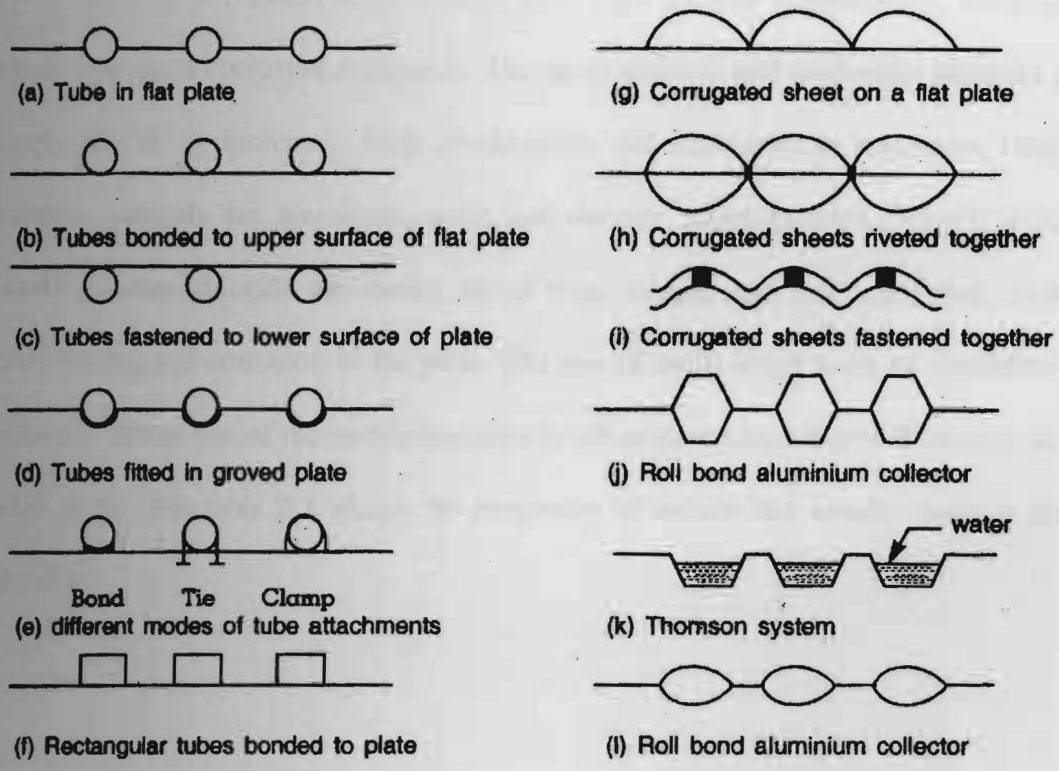

Figure 2.5 Cross-sections through collector plates.